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ABSTRACT

The cognitive processes involved in a child's interaction with the linguistic environment are discussed. Specifically, the general cognitive processes involved in outputting long spans of connected utterances are examined. Narrative data are classified into three developmental levels: the procedural phase, where the linguistic output is generated by data-driven processes; the metaprocedural phase, where the output is generated by top-down control processes; and a third level characterized by a dynamic interaction between data-driven and top-down control processes. These three levels form a model to account for how children constantly solve problems when they produce and perceive language. Children need to generate processes for the mapping between linguistic terms and extralinguistic referents. They need to generate processes for dealing with local syntax in order to produce well formed utterances. In addition, they need to generate processes for linking spans of utterances into a cohesive unit. The process oriented approach is a useful technique for understanding these needs and offers a way to rethink the relationship between cognition and language. (RW)

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LANGUAGE DEVELOPMENT AS A PROBLEM-SOLVING PROCESS[1]

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1. Introduction

Over the last few years, my psycholinguistic work has mainly concentrated on the specifically intralinguistic aspects of child language acquisition in a scientific climate where the role of communication was centre-stage. My concern was to show that socio-communicative reductionism cannot account for several major aspects of language development. I set out to demonstrate that children go beyond successful linguistic representation of their ideas and beyond successful communication with addressees (Karmiloff-Smith, 1979a, 1979b). The position I argued for was that, from very early on, children work on their linguistic representations, treating language as a formal problem space per se. Successful communication, in my view, is the product of the child's linguistic problem-solving activity rather than the motor for it.

However, although I have been stressing the intralinguistic aspects of children's language acquisition, I do not look upon myself as a psycholinguist. Just as Molière called Sganarelle "Le Médecin Malgré Lui", so I might be thought of as a "psycholinguiste malgré moi"! Indeed, when I was invited to address this forum devoted entirely to child language - and I should like to warmly thank this year's committee for giving me this privilege - the invitation plunged me into my habitual scientific schizophrenia! I believe an explanantion will serve to clarify my particular way of viewing language acquisition. I have always been concerned with both language acquisition and children's non-linguistic problem solving, and my interests continue to flip between the two. When I am engulfed in a problem-solving phase, I may spend two or three years without doing any new research on language acquisition, and vice versa. But at conferences, my scientific schizophrenia rears its head, despite a seemingly clear distinction between my two domains of interest. Thus, when at a meeting on problem solving, I find myself stressing the relevance of the processes of language acquisition and when, as today, the meeting is on language acquisition, I am overcome by the urge to demonstrate the relevance of problem solving. That is why I feel most at ease in cognitive science gatherings because they don't seem to worry which area I choose to illustrate my arguments! The compromise solution for meetings on language acquisition has been that I indeed concentrate on language, but nonetheless add a little spice, with a sentence here and there on the relevance of problem-solving processes to language development. However, I decided to use the opportunity of this address to focus more deeply on the rationale behind a problem-solving, process-oriented view of language acquisition.

It is a truism to state that language acquisition is an exceedingly complex process, with many interacting factors. Yet

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when reading the literature, one gets the impression that, one day, someone is expected to come up with the clue to language acquisition. Numerous articles implicitly or explicitly conclude that the explanation for language acquisition will be found in one of the following: the linguistic properties of the input, the pragmatics of socio-interactive patterns, innate linguistic constraints, cognitive constraints, etc. etc. When counterarguments or disconfirming data about the explanatory value of any one of these aspects are adduced, the authors claim to have eliminated the need for any further consideration of that particular aspect in a model of language acquisition. This is somewhat of an exaggeration, for some theorists do argue explicitly for an interactive approach, but I still believe the generalisation to be valid for much of the child language literature. So, truism as it may be, it is worth reiterating that many factors will have to be accounted for in a complete model of language acquisition. What needs to be determined is not which one of them explains language acquisition, but rather what the relative weightings of all the different factors are. These weightings should not be viewed as static, since the different factors may interact differently at different moments of the long process of language acquisition.

One of these factors concerns the cognitive processes involved in the child's interaction with the linguistic environment: how children explore language; how they analyze and reorganize their linguistic representations; how they take language as a formal problem space and not merely as the vehicle for communication or the representational tool of cognition. I believe that an account of such processes must be an integral part of a complete model of language acquisition, rather than merely being considered as peripheral to a linguistically-oriented model. Thus, as a sort of counterweight to the albeit welcome swing of this year's SFRCL programme towards the more specifically linguistic aspects of language acquisition, I will centre my talk on the processes children use in order to output the linguistic data I have collected. I shall then apply the process-oriented approach to an area which has nothing to do with language, i.e. problem-solving processes in a physics task. My thesis will be that there are important equivalences between children's processing of these two different domains. Finally, some questions will be raised about the source of the common processes and what they suggest with respect to the representational systems of human and non-human primates.

2. Stages, phases and levels in development

An important terminological distinction I wish to stress in this paper concerns the difference between "stage" and "phase". A stage designates a stretch of time that is characterised by a qualitative change with respect to both the preceding and following stages. For the term "stage" to have any theoretical depth, it must in my view cover more than one particular domain of development and account for children's approach to a variety of different domains. This is how Piaget used the term stage and why so much of the anti-Piagetian

literature regarding specific domains is irrelevant. To designate changes within a specific domain, I shall use the term "level". Thus, when I refer to the development of children's narrative productions, I will refer to three different developmental levels. However, when drawing analogies across domains (e.g. language and physics), I shall make use of the term "phase", since I wish to argue for a 3-phase recurrent process across different ages[2]. In other words, when I refer to phase 1, 2 or 3, they should not be linked to a particular age because I shall endeavour to demonstrate that these are generalised processes by which children interact with new problems at all ages of their development. In presenting the recurrent phase model I take no position in this paper on whether development cannot also be characterised through stages. My aim is different to the stage approach in that the model I will present attempts to account for common processing in linguistic and non-linguistic development. The general issue of the relationship between language and thought can, in my view, gain from this process-oriented approach.

3. Comparing linguistic and non-linguistic development

Before embarking on this, it is important to explain the level at which the comparisons will be made. There are three types of comparison which might be made between linguistic and non-linguistic development: a) structural comparisons, b) content comparisons and c) process comparisons. Seeking common structure or content implies in most cases a stage-like approach to development. By contrast, the search for common processes does not necessarily imply stage-like sequences.

Let me illustrate these points. A typical structural approach can be found in the writings of the Genevan psycholinguistic interpreters of Piagetian theory. The child's acquisition of syntactic structures is explained by the prior acquisition of non-linguistic structures, although no hypotheses have ever been entertained as to how such direct mapping might actually take place. The following citations exemplify the structural equivalence position: "... this 'group' of (sensori-motor) action patterns also serves as a heuristic model for the acquisition of syntax and it is precisely what the child (every child) has learned during his first 18 months or so that provides him with the necessary and sufficient assumptions to start this acquisition" (Sinclair 1975, p.232); "...the stages of cognitive development (which) in our opinion, determine the nature and the form of the linguistic structures that children are able to produce and understand" (Ferreiro and Sinclair, 1971, my italics).

For example, it was argued that passive sentences are not understood until the logical operation of reversibility is acquired (Sinclair & Ferreiro, 1970). These authors argued, from a Chomskyan point of view on language, that passive sentences were the result of a transformation on the deep structure of the corresponding active sentences. This linguistic operation was then equated with the logical transformation of reversibility, imputed to children at the

Piagetian concrete operational level, and which was seen as the precondition for understanding passive construction. The supposition regarding the direct meaning and/or transformational relationship between active and passive sentences has come under attack from many linguists. Moreover, the unsubstantiated direct mapping suggested by the Genevans between such alleged transformations and cognitive structures is open to considerable criticism. But an evaluation of the position is not my purpose here. It is merely to provide an example of a structural approach to the language-cognition comparison.

The quest for content equivalences is somewhat different. It involves stage-like sequences within specific domains rather than across different domains. There have been such attempts both in Piagetian and non-Piagetian approaches, too numerous to reference here. As an example, content approaches can be found in the comparison of spatial concepts and spatial lexemes or, say, of temporal concepts and temporal lexemes. The argument has been that the acquisition of the specific conceptual knowledge is a prerequisite for the acquisition of the corresponding linguistic terms. In such comparisons, language is considered, implicitly or explicity, to be the outcome of cognitive development. Thus when studying spatial terms, comparisons are only made with corresponding spatial concepts. Yet when the child discovers something relevant about contrasting spatial terms, she may well apply that knowledge also to temporal terms, e.g. the child could deduce from the contrastive spatial terminology the fact that a distinction is encoded and apply the notion of distinction to expressions about time, without necessarily awaiting the full development of the corresponding temporal concepts. This makes room for a two-way arrow, where cognition clearly affects language development, but where also the processes of linguistic encoding operations (and not narrowly their specific content) can affect cognition. In general, both language/cognition comparisons and cross-linguistic comparisons are often too content-restricted. As I have argued elsewhere with respect to cross-linguistic analogies (Karmiloff-Smith, 1978), we should not necessarily compare, say, relative clauses in three different languages, but find out first what the function of the relative construction is in one language and then ascertain whether this same function is not expressed by another structure in the other language. It is the functional comparison that bears the most fruit in developmental psycholinguistics also.

Despite my criticisms of the structural and content approaches, I do not deny that some structural analogies and some content analogies may have their roles to play. Yet, as I shall argue in this paper, a much larger place needs to be given to comparisons of processes than has hitherto been the case.

With these various distinctions in mind, I should like to start with a discussion of children's story-telling. In previous papers (Karmiloff-Smith, 1980, 1981), I analysed the specifically linguistic aspects of the development of children's use of cohesive markers in narratives. At that time, my aim was to demonstrate that

the "sentence" was the wrong unit of analysis for understanding anaphora both in linguistics and in language acquisition. I endeavoured to show that rules at the sentence level, such as the minimum distance principle (Chomsky, 1969), parallel function strategy (Sheldon, 1974) or parallel semantic role (Ferreiro et al, 1976), could not account for the use and non-use of pronouns, full noun phrases and zero anaphora in discourse.

In this paper, my aim is different. Using the same linguistic data I have tried to identify the general cognitive processes involved in outputting long spans of connected utterances. A three-phase model will be applied to these processes in language acquisition as well as, later in the paper, to the processes of children's interaction with non-linguistic problems. The examples chosen to illustrate the model are from narrative productions and block balancing. However, it is essential to note that this paper is not focussed on the acquisition of either narratives or block balancing per se. These data will be used merely to corroborate another, more general level of analysis. Thus I will not reference all the relevant work on children's narrative acquisition nor on the law of Torque. The appropriate references for the present process-oriented comparison of language and cognition might be data on children's use of, say, wh-questions compared with their understanding of, say, weight. This is obviously an invented example to stress the difference between the process-oriented comparison and content comparisons. In fact, I have been unable to find any attempts at process-oriented comparisons between linguistic and non-linguistic development in the literature outside my own work (Karmiloff-Smith, 1979c and in press, b). However, in the 1979c paper, I compared macrodevelopmental changes in language acquisition with microdevelopmental changes in children's generation of a spontaneous notational system which would serve them as an external memory device. Both cases were concerned with semiotic codes and the comparison was made in one case with macrodevelopment and in the other case with microdevelopment. Thus the earlier comparison may bave been less convincing than the one I shall attempt to make in this paper. Here the comparison will use macrodevelopment in both cases and compare language development to a domain of physics which has no relation to a conventional semiotic code.

For the purposes of this paper, I shall invoke a psychological view of syntax. Of course a language acquisition model will have to account for the specifically linguistic component of syntax. But I submit that a satisfactory model must also account for the more psychological aspect of syntax as the general organizational property of language. This more general view of syntax will bring out the common organizational properties between children's language and their processes of interaction with non-linguistic domains. It will support my view that models of language acquisition must include a higher level of description which attempts to cut across domains rather than be restricted to the specific domain of language. In stressing this organizational characteristic of syntax, my concern is to situate language as a process occurring in real

time, i.e. not as a static model of grammatical rules. Thus, for example, when later in the paper I refer to subordinate clauses, I will not be accounting for their particular syntax with respect to other linguistic structures, but rather for their organizational function in a flow of discourse.

4a. A linguistically-oriented analysis of children's narratives

The narrative experiments to be discussed below were based on asking children to tell stories from picture booklets with no text. Some of the books had a clear central character, some had two characters of different sex, some had three, while others were merely a series of six disconnected pictures. (Details of the experimental procedure, population, etc., can be found in Karmiloff-Smith, 1980 or 1981). In the earlier analysis of this work, I stressed a number of linguistic issues. To make clear the contrast between my previous analysis of the data and the analysis done for this paper, a brief description will be presented here of the linguistic developments. I do this for contrastive purposes, as an invitation to you to read with a somewhat non-linguistic eye what I shall write afterwards about children's narratives.

Children's narrative productions were divided into three levels. At level 1 the youngest children use pronouns and full NPs in their deictic function. At level 2 children start to use referential expressions in their discourse functions. First, they introduce a referent with an existential expression, or, if the referent is already shared knowledge with the addressee, then a definite referential expression or a proper name is used. The child then implicitly raises the following question: is there a main protagonist involved in a sequence of events? If the answer is affirmative, the child creates a thematic subject and generates a series of reference-maintenance procedures and constraints. The output is governed by the thematic subject constraint, which preempts pronominalization and zero anaphora in initial utterance slot for the thematic subject. As the narrative unfolds, the thematic subject constraint acts as an instruction to the addressee not to recompute pronouns for retrieval of the antecedent, but rather to take all pronouns to refer by default in subject position to the thematic subject. This also places constraints on the lexical choice of verbs and on voice, because the initial slot is occupied by the thematic subject. It likewise constrains the positioning and types of referring expression used for non-thematic subjects. With development, level 3 children allow non-thematic subjects occasionally to occupy initial utterance slots. However, when doing so, they use clear linguistic markers to this effect. These are an implicit instruction to the addressee to create a temporary slot variable, but none the less to hold interpretation of direct pronominalization open for the thematic subject, as the default case. Indeed, children continue to pronominalize directly for the thematic subject, despite intervening sentences, but they carefully monitor the interplay between the discursive and local sentential levels. The repetition of a full noun phrase is not

used to avoid ambiguity, nor is a pronoun used to avoid uneconomic repetition. Rather, the use and non-use of pronouns and other referring expressions serve to organize ongoing discursive relations.

If the answer to the earlier question regarding a main protagonist involved in a sequence of events is negative, older children either invent a thematic subject not actually in the story but through which they hold the story together, or they avoid pronominalization except within utterance boundaries with connectives. In this second case, children tend to repeat full referring expressions for the same referent across utterance boundaries until a thematic subject can be established. If no thematic subject emerges, children monitor their narrative at the local intra- and inter-sentential levels. In contrast to stories obeying the thematic subject constraint, in the case of stories with no thematic subject, it is the action involved which dictates the lexical choice of the verb, and it is the verb choice which constrains the filling of utterance slots, the type and positioning of referential expressions.

4b. A process-oriented analysis of children's narratives

Having given the flavour of a more linguistically-oriented analysis of children's story-telling, (for full details, see Karmiloff-Smith, 1981), I now wish to subject the narrative data to a different, complementary analysis involving general cognitive processes. The picture that emerges from the new analysis also falls into three developmental levels as follows: at level 1, which I call the procedural phase, the linguistic output is generated by predominantly data-driven processes. The child generates success-oriented procedures in order to describe the contents of each picture. Each utterance is correct syntactically and has rich lexical variety. In this respect, the child is successful. However, the narrative is not organized as a single unit by the child. A series of correct utterances are juxtaposed locally, but lack the organizational property of a single narrative unit. The addressee hears the output as if it were a unit, but I contend that this is not the case with respect to the processes the child uses to generate each of the utterances of the narrative.

At level 2, which I call the metaprocedural phase, the linguistic output is generated by predominantly top-down control processes by which the child monitors the flow of her connected utterances. Contrasted with level 1, the narrative is poor in lexical variety and weak on story details. In fact, it may even violate truth conditions. Yet, as a narrative, it is a single unit, with utterances linked within an overall organization. Unlike the success-oriented procedures of level 1, the level 2 child works on the procedural representations by the use of organization-oriented procedures. To organize the whole into a single unit, the child generates a simplified but rigid procedure, preempting utterance initial position for references to the thematic subject of the narrative.

The third level is characterised by a dynamic interaction

between data-driven and top-down control processes. Lexical variety is again rich. The story details are much fuller than at level 2 but are coordinated with the top-down control mechanism which organizes the narrative into a single unit. Through the process of interaction the child produces differential linguistic markers according to the dynamics of the progressively unfolding discourse.

A number of examples will illustrate these developmental levels of children's narrative production. The first three examples are from the booklet which contained six pictures not clearly related one to another. To generate a "story", the child needs to introduce some external factor not included in the pictures. A large number of level 1 children used deictic pronouns for all their stories. But to pinpoint aspects of the narrative other than their deictic ambiguity, I have chosen for this story a level 1 example where full noun phrases were used (the definite article is functioning deictically here too). Examples 1, 2 and 3 are taken from levels 1, 2 and 3 respectively.

Example 1: "There's the rabbit riding a bike and...the two cats are playing tennis and...the dog's kicked a goal and the rabbit's drawing a line 'cos the turtle's won the race and the fox is playing his trumpet and...the dog's singing with his guitar."

Example 2: "There is a rabbit riding a bicycle and he...sees two cats and he...draws a line for the turtle and he...sees a dog with a ball and then he sees a fox playing music and then he...hears some more music."

Example 3: "Well there's a rabbit going for a ride on a bicycle and he passes by two cats who're playing tennis, and then another rabbit...his friend, is drawing a line. It's the finishing line for the bicycle race. And then he rides by a dog playing football, and then there's a fox cheering him with a trumpet and then they all have a party because he won the race."

In example 1, the lexical variety is rich. The syntax of each utterance is locally correct and the details of the pictures are fully rendered in the linguistic output. However, comparing this to examples 2 and 3, I contend that the level 1 child's linguistic output is predominantly data-driven. The child has a series of procedures which function correctly for describing the physical stimulus in each picture. Details are attended to and the corresponding linguistic terms are accessed and output, utterance by utterance. Not only is the local syntax correct, but the overall syntax is correct in this case since the child used full noun phrases, happening thereby to avoid ambiguity of reference which would have occurred with pronominalisation. The location of pauses, after the connective "and", is particularly revealing. Contrary to the protocols of older children, the "and" plus pause in example 1 seems to function as a connective between outputs rather than as a connective between sentences. The output does not form a single linguistic unit. For the child it is a series of juxtaposed utterances. These points are borne out by what follows

developmentally in this and other stories. Nonetheless, it is important to note that the level 1 productions seem to be very successful.

Compared to example 1, example 2 does not represent faithfully and fully what was in the pictures; there was in fact no rabbit in each picture observing a series of events. The way this story was told violates the truth conditions relating to the stimulus. Example 2 is poor in lexical variety and very weak on picture content. However, given that younger children can describe the contents of each picture accurately and can access the right linguistic terms, it is impossible to explain the output of example 2 on the grounds that the older child experienced problems of lexical access. My explanation is that the child has generated a top-down control process by which she can monitor her own output as a single unit. The development of narrative is not simply the gradual introduction of cohesive markers to an already complex lexicon and syntax. The generation of the top-down control process represents a qualitative change, resulting in superficially weaker output. Yet even if there is a loss in content, it constitutes a gain in its organizational properties.

In example 3, we again detect a top-down control mechanism at work, organizing the narrative as a unit. But details of the stimulus pictures have now been reinstated, yielding an interaction between data-driven and control processes. From the viewpoint of narrative details, levels 1 and 3 are fairly equivalent through their use of data-driven processes. By contrast, from the viewpoint of narrative organization, it is levels 2 and 3 which are close because of the use of the top-down control mechanism. But level 3 differs from both of the others in that the two processes are now coordinated smoothly.

Examples 4, 5 and 6, from a story about a boy and girl fighting over a bucket, are taken from levels 1, 2 and 3 respectively.

Example 4: "There's a boy and a girl. He's going fishing and she's going to make sandcastles. So he takes her bucket and...she tries to grab it back and he runs off with it, so she sits there crying by the tree. Now he can do his fishing. He got four fish."

Example 5: "There's a boy and a girl. He's going to catch fish so he takes the girl's bucket and he runs off and catches lots of fish."

Example 6: "There's a girl and a boy. The boy wants to go fishing, so he tries to get the girl's bucket, but the girl won't let him take it, so he grabs it out of her hand and the girl chases after him, but he gets away from the girl and he starts to fish while the girl sits there crying. He goes home smiling with four fish."

In example 4 from level 1, we can once again note the rich lexical variety. The syntax is locally correct and, given that the two protagonists are of different sexes, all the pronominal references happen to be non-ambiguous. There is no ambiguity of reference, no gender errors, no syntactical errors and no incorrect lexical mapping. Whilst there is some local connection between

utterances, the overall ouput is generated by data-driven processes describing each picture. Unlike the disconnected pictures in the first story, those in this story are held together by their content. This very fact makes the child's output appear more cohesive than it actually is. For the addressee, this sounds very much like a story. However compared to the narratives from older children of levels 2 and 3, the output is not yet a single unit for the child. My argument becomes stronger once cases are considered where natural gender does not disambiguate referents (see example 7 later). But it is important to stress that the level 1 productions seem to be very successful.

Example 5 is a typical story from level 2. Together with reduced lexical variety, the details of the pictures are almost completely lost. The boy in the story is in the subject slot of each utterance and is pronominalised, whereas the girl is hardly referred to at all, which contrasts totally with example 4. Despite the loss of detail, the level 2 child is using a top-down control mechanism, treating the narrative output as a unit.

Recall that in example 4 from level 1, the child pronominalised both protagonists throughout. The pronouns were non-ambiguous because of the gender distinction. In example 6, from level 3, by contrast, only one of the protagonists, the thematic subject, is pronominalised. Almost all references to the girl are with full noun phrases. These full noun phrases cannot be explained by an attempt to avoid potential ambiguity of reference because, when told with pronouns throughout, the story is completely unambiguous. Why does the child produce: "so he tries to get the girl's bucket but the girl won't let him take it", instead of : "so he tries to get the girl's bucket but she won't let him take it?" Why does the child produce: "the girl chases after him but he gets away from the girl", rather than: "he gets away from her" or "the boy gets away from her?" Clearly, the child has preempted pronouns to refer to the boy, and full noun phrases to refer to the girl. In my view, the pronouns used in example 6 to refer to the boy are of a qualitatively different nature to the same pronouns used to refer to the boy in example 4. In that example, I would argue the child has mapped the correct natural gender features on to the extralinguistic referent ("he" refers to the boy in the pictures, and "she" refers to the girl). In example 6, by contrast, the pronoun no longer refers to the extralinguistic referent but rather to the highest node (the thematic subject) in the child's internal representation of the discourse as an organized unit. Here again, the smooth interaction can be noted between the data-driven processing of details of the story and the top-down control mechanism which treats the discourse as a unit, generating differential markers (pronouns versus full noun phrases) for reference to the protagonists.

Examples 7, 8 and 9, from the three levels respectively, are taken from a story about a boy and a balloon vendor.

Example 7: "There's a little boy in red. He's walking along and he sees a balloon man and he gives him a green one and he walks off home and it flies away into the sky so he cries."

Example 8: "There's a boy going along. He gets a green balloon, he lets go of the balloon and he starts crying."

Example 9: "A little boy is walking home. He sees a balloon man. The balloon man gives him a green balloon so he happily goes off home with it, but the balloon suddenly flies out of his hand and so he starts to cry".

Example 7 demonstrates that when the story content does not by chance facilitate the correct use of referential devices (as in the gender distinctions of the bucket story), then the argument that the child is not treating the overall output as a single unit becomes more convincing. The referential devices used in example 7 are ambiguous for the addressee. However, if the addressee treats each pronoun as a separate unit referring only within each utterance to the person involved in the action it describes, then these deictic pronouns are not ambiguous. It is when we treat the pronouns as discursively referential that they are ambiguous. My argument is that the level 1 child is not making discourse reference, but local utterance reference.

Example 8, by contrast, is discursively referential, but suffers from the shortcomings of level 2 outputs, discussed above for examples 2 and 5. Finally, example 9 illustrates the use of differential marking of referential expressions, typical of level 3, when data-driven and top-down control processes interact smoothly.

In much of my previous work, self-repairs were used as an important source of corroborative data (Karmiloff-Smith, 1979a, 1981a, in press, a). They often serve as a clue to the transition between two levels. Self-repairs may be frequent or infrequent but, in my view, quantitative arguments may be far less relevant than interpretations based on the qualitative nature of the repairs (Karmiloff-Smith, 1981b). None the less, the first repairs to be discussed below actually occurred very frequently in the data. Example 10 is a literal translation of a French protocol. Right dislocation did not occur in the English protocols. It should be pointed out that in French right (and left) dislocation is very common; this narrative sounds completely natural in French, even if in translation it is somewhat awkward.

Example 10: "Well it's a girl and a boy. The boy he wants to fish, so ne takes the bucket. And she tries to stop him, the girl. But he keeps it and the girl runs after him. Even so he continues to fish. She sits on the tree trunk and she starts to cry, the girl. And him, he catches a few more fish."[3]

This is a revealing illustration of the interaction between top-down and data-driven processing but which is not yet as smooth as level 3 outputs. To be noted is the fact that the child postposes a full noun phrase to disambiguate reference to the girl, but never does this in reference to the boy although, as the narrative is told,

references to the boy are just as potentially ambiguous as those to the girl.

Example 11: "This boy and girl are out playing. He's gonna catch some fish but she..the girl won't lend him her bucket. So he just takes it and the girl gets real sad."

In this example, the child could easily have continued "but she won't lend him her bucket." There would be no problem of referential ambiguity. Yet again, it is the boy who is pronominalised and the girl who is referred to with full noun phrases, in order to mark the discursive structure of the narrative rather than to obey any local syntactic constraints. These two examples, and many others like them, are eloquent demonstrations of how the top-down procedure, guided by the representation of the overall narrative structure, overrides any local organizational constraints. Had the child been treating each utterance as a separate unit, with each one correctly mapped onto the physical stimulus of the pictures, no repairs should have occurred. However, when the hypothesis is accepted that the child is attempting to organize the narrative as a unit, the repairs become interpretable.

At this intermediate level, children are grappling with the interaction between data-driven processing of the story details and the control mechanism which constrains the overall structure of the output. Some of the pictures lend themselves to being described in a particular way and repairs are necessary when the control mechanism cannot absorb data-driven processing of story details. In the case of the balloon story, I demonstrated experimentally that for level 1 subjects, the linguistic output for a picture described in isolation was identical to the output when the same picture was part of a series forming a story. By contrast, level 2 and 3 subjects produced different outputs in the case of the stimulus in isolation versus its insertion into a story (Karmiloff-Smith, 1981). In the case of the isolated picture, it is the action which dictates the level 2 and 3 children's lexical choice of verb (e.g., the man gives the boy a balloon) whereas in the case of insertion of the identical picture into a connected series, it is the thematic subject constraint (preemption of initial sentence slot: e.g., the boy wants a balloon) which determines their different verb choice. For level 1 subjects, by contrast, the verb "gives" was used in both cases.

The next type of repair was found in less than one per cent of my data. Nonetheless, I judge them to be meaningful in that, as argued above, a qualitative evaluation of data can often be more fruitful than a quantitative one, particularly where used in conjunction with other data emanating from a very large number of subjects.

Example 12: "There's a boy and a girl. He's trying to fish. And to get her bucket, he hits the girl and she star..he hits the girl who starts crying. But he just ignores her and goes on catching fish."

Example 13: (Halfway through the balloon story) "(....) He meets a man selling balloons and he gives the boy...a man selling balloons who gives him a green balloon. He goes off really pleased. (....)"

Example 14: "There's a boy and a girl playing together. But he wants to go off and fish and so he pinches the girl's bucket. He runs quickly away, so he starts to fish and the girl...leaving the girl crying."

In these three narratives the child need not have repaired. There is no local utterance level at which these repairs are meaningful. They cannot be due to difficulty of lexical access; in all three cases, the child had emitted the locally correct continuation word. Again, my explanation for these repairs is that the child is motivated by the organizational constraints of the overall narrative structure while monitoring the flow of discourse. But why does the child use subordination structures when repairing? It is well known that in middle childhood children have acquired procedures for outputting subordinate clauses. My concern here is clearly not at what age subordinate clauses are acquired, but rather the psychological function the clauses might serve in discourse for children. We have seen from other examples discussed above that children generate a fairly rigid top-down control mechanism to output their narratives as a unit. The thematic subject constraint forces the child to find means of avoiding the occupation of initial utterance slots by anything but references to the thematic subject. At level 3, this is resolved by the use of differential markers in any position. At level 2, the problem is solved by simply leaving out story details. Another solution which appears to be intermediate between levels 2 and 3, illustrated in examples 12, 13 and 14, is to retain the details but to subordinate them to the thematic subject constraint. My argument is that, as the output of the discourse gradually unfolds in real time, the child is guided by a spatialised linear representation. To mention non-thematic subjects, the child needs to avoid referring at the same level. The solution is to subordinate the reference to non-thematic subjects to a level below the ongoing linear representation. It is with respect to such a spatialised representation that relative and other subordinate clauses take on their syntactic organizational function in discourse. The thematic subject is referred to at the uppermost level of the linear representation and can be pronominalised directly. The repairs occur when the child finds herself using a referential term at the "wrong level". Subordination structures can thus be analysed not only from a strictly linguistic stand with respect to syntactic constraints but also from a psychological stand with respect to their organizational properties in extended discourse.

5. Language as problem solving: a 3-phase model

To sum up, children are constantly solving problems when they produce (and perceive) language. They need to generate processes

for the mapping between linguistic terms and extralinguistic referents. They likewise need to generate processes for dealing with local syntax in order to output a wellformed utterance. But they also have to generate processes for linking spans of utterances into a cohesive unit. Processes of both a linguistic and more cognitive organizational nature must be generated for coping with the intricate interaction of these different aspects of language production. This takes its course gradually over development. An initial predomination of data-driven processing, is followed by a period of rigid top-down control. Ultimately, after a period of self-repairs, a smooth interaction is attained. This occurs recurrently for each aspect of language. Even adult discourse requires a fine-tuned monitoring of the interaction between these different lexical, syntactical and discursive processes as language is output in real time.

Although it may at first seem stylistically redundant, I will repeat below the description of the three levels of narrative development, which was given towards the beginning of this paper. The repetition is aimed at enhancing the evaluation of the subtle terminological changes I shall introduce for the subsequent comparison with processes at work in a non-linguistic domain.

At level 1, the procedural phase, the linguistic output is generated by predominantly data-driven processes. The child generates success-oriented procedures in order to describe the contents of each picture. Each utterance is correct syntactically and has rich lexical variety. In this respect, the child is successful. However, the narrative is not organized as a single unit by the child. A series of correct utterances are juxtaposed locally, but lack the organizational property of a single narrative unit. The addressee hears the output as if it were a unit, but this is not the case with respect to the processes the child uses to generate each of the utterances of the narrative.

At level 2, the metaprocedural phase, the linguistic output is generated by predominantly top-down control processes by which the child monitors the flow of her connected utterances. Contrasted with level 1, the narrative is poor in lexical variety and weak on story details. In fact, it may even violate truth conditions. Yet, as a narrative, it is a single unit, with utterances linked within an overall organization. Unlike the success-oriented procedures of level 1, the level 2 child works on the procedural representations by the use of organization-oriented procedures. To organize the whole into a single unit, the child generates a simplified but rigid linguistic procedure, preempting utterance initial position for reference to the thematic subject of the narrative.

The third level is characterised by a dynamic interaction between data-driven and top-down control processes. Lexical variety is again rich. The story details are much fuller than at level 2 and are coordinated with the top-down control mechanism which organizes the narrative into a single unit. Through the interaction, the child produces differential linguistic markers according to the dynamics of the progressively unfolding discourse.

I should now like to restate the three levels in a somewhat different terminology, abstracting from the linguistic context and replacing it by more general, but just as detailed, formulations. In doing so, my intention is to avoid violating the richness of the data in any way. The term "level" will be replaced by "phase" because, whereas the linguistic account in terms of three levels is intended as a model of development within a particular domain, the more general reformulation is aimed at providing a recurrent 3-phase model applicable throughout development as the child comes to grips with any new aspect of any domain.

In phase 1, the procedural phase, the behavioural output is generated by predominantly data-driven processes. The child generates success-oriented procedures and takes environmental stimuli carefully into account, involving positive and negative feedback. Each behavioural unit is rich and usually successful in achieving its goal. However, each output is merely juxtaposed to the previous one. During this first phase there are no attempts at overall organization which would link behavioural units one to another. The observer may interpret the child's behaviour as if it were generated from a single control mechanism, but this is not the case with respect to the processes the child uses, which are recomputed separately for each part of the problem.

In phase 2, the metaprocedural phase, the behavioural output is generated by predominantly top-down control processes by which the child monitors her flow of behaviour. Contrasted with phase 1, the behavioural output appears limited in scope. In fact, the child may ignore negative feedback from the environmental stimulus, but this is as a consequence of an overall organization dominating the behaviour. The child now treats that which was previously a series of isolated units as a single one. Unlike the success- oriented procedures of phase 1, the phase 2 child works on the procedural representations by the use of organization-oriented procedures. To organize the whole into a single unit, the child generates a simplified but rigid procedure to treat all outputs within a single framework.

The third phase is characterized by a dynamic interaction between data-driven and top-down control processes. Environmental stimuli are taken into account and coordinated with the top-down control mechanism which organizes the whole into a single framework. Neither the environmental feedback nor the control mechanism predominates, but the control mechanism loses its rigidity, allowing for subtly modulated output.

I submit that this covers adequately, in non-linguistic terms, the linguistic data analyzed in this paper. However I would further submit that it models equally well data from a problem-solving task which has nothing to do with language.

6. Problem solving in a physics task

The data concern children's block balancing in a task I designed a number of years ago (see Karmiloff-Smith and Inhelder, 1974 for details; see also Karmiloff-Smith, in press, b). Suffice it to

say that children were asked to balance a large number of blocks on a small metal bar. Some blocks balanced at their geometric centre, some slightly off centre, due to weights stuck conspicuously to the blocks. Some balanced at one extremity given that lead had been drilled inside the wooden blocks. These I called inconspicuous-weight blocks since, on the surface, the blocks looked exactly like those which balanced at their geometric centre. There were several duplicates of each block type. The child was asked to balance on the metal bar, each of the blocks, one after the other, selecting them in any order.

Very briefly, the results of this study can be divided into three levels. At the first level, children were successful in balancing each of the blocks. They simply moved the block back and forth along the metal bar until they found the point of equilibrium. They used proprioceptive feedback and corrected the position of contact accordingly. However, when they were successful in balancing, say, a conspicuous-weight block, they did not go on to try another conspicuous-weight block immediately afterwards. Rather, they simply took up each block as it lay on the table and successfully balanced it. They never used information just gained about the point of balance of a particular block, but treated each block as an isolated problem.

At the second level, the behavioural pattern was totally different. Children took each block, tried the geometric centre and, where the centre of gravity did not coincide with the geometric centre, the children simply put those blocks aside, remarking that they could not be balanced. They did not make the rich corrections that the younger children made via the proprioceptive feedback. Moreover, if the experimenter placed one of the complex blocks in equilibrium and then asked that an identical one be balanced alongside, the child still tried the complex block's geometric centre and concluded that it just would not balance. Their behaviour was rigid, applying a simple procedure across all blocks, ignoring particular details of the stimuli and the proprioceptive feedback.

At the third level, the children tried the geometric centre first, but rapidly moved the block along in one direction or the other, using the proprioceptive feedback until success was achieved. Once they had worked out where a conspicuously-weighted block could be balanced, they would seek a similar one, using the information just gained. This contrasts with the behaviour at level 1 where children treated each block as a separate problem. At level 3, there is smooth interaction between the top-down control mechanism and the data-driven feedback.

7. Evaluating the 3-phase model

Even from this very brief account of what happened in this physics task, it is possible to evaluate the three levels in terms of the 3-phase model outlined above. I trust this demonstrates that if we are able to pitch the level of analysis correctly, we can compare the processes of language acquisition and of non-linguistic problem-solving, without doing injustice to the analysis of either

domain. When the level of comparison is pitched too high, then we can do little more than state that cognition antedates language or vice versa. When the level is pitched too low, then comparisons are made impossible. For example, an underlying representation of symmetry may explain why children come to create the geometric-centre theory. Symmetry may indeed account for a number of procedures children use (Karmiloff-Smith, 1975; Piaget & Karmiloff-Smith, in press). However invoking the notion of symmetry alone does not allow for the comparison with children's narrative development, nor with other aspects of children's problem solving (Karmiloff-Smith, in press, b). It is the wrong level of analysis for the equivalence I am trying to establish. Likewise, perspective-taking is a concept which might contribute to the analysis of the results of the narrative study. However, once again, although invoking perspective-taking is useful for describing the levels that obtain for the narrative data, it is pitched too close to content to allow us to discern the relationships which exist betwen language production and physics. Thus, I submit that the level at which I have pitched the 3-phase model involves no violation of either domain, and allows me to make a rich comparison between linguistic and non-linguistic cognition.

Had I made a comparison between the results of the block-balancing task and children's development of the past tense marker "-ed", I might have characterized phase 2 by the notion of "over-generalisation". But this descriptive term would not account for phase 2 in the narrative study. The notion of over-generalisation captures the interaction of simplification and unification, but it is of less general application than the explanatory notion of metaprocedural processes. Overgeneralization is merely a special case of the general concepts invoked for metaprocedural phase 2.

I have been using the terms "top-down" and "metaprocedural" almost interchangeably. I did it on purpose because in earlier papers (Karmiloff-Smith, 1979a, b, & c, 1982, etc.), "metaprocedural processes" have been mistakenly taken by readers to imply some form of conscious reflection. The "top-down" notion captures intuitively part of my conception, but the term "metaprocedural" is intended to capture something more. The model that I have been developing over the last few years gives a predominant place to <u>meta</u>processes. I consider them to be an essential component of acquisition. The concept of metaprocesses should not be confounded with that of metacognition where "meta" implies conscious verbal explanation on the part of the child. In my use of "meta-procedural", I wish to stress the fact that the new procedures are at a different and meta level to those operating initially, with no necessary requirement of conscious awareness, although there could be. My argument has been that children initially work at achieving a successful one-to-one mapping between specific linguistic forms and the particular extralinguistic/pragmatic context to which each form most suitably refers. When one linguistic form refers to different contexts, these are first stored as many independent, identical form-function pairs. This argument with respect to

lexemes can also be applied to full utterances. Utterances are first the result of successful one-to-one mapping. Once the procedures for such mapping operations function efficiently and become automatised, the child then works metaprocedurally, linking the utterances into a discourse structure.

Clearly the interplay between procedural and metaprocedural processes needs the insertion of a yet-to-be specified mechanism which would continuously evaluate, across all the various parts of the developing systems, the moment at which any one of them was ripe (i.e., automatised, consolidated, functioning efficiently...) to be operated on metaprocedurally. At this stage of my thinking, it is only be assigning arbitrary numerical values for, say, temporal distance between T_1 (juxtaposed isolated procedures) and T_2 (metaprocedural processes), or for frequency of use, generalisation of use, stability of output, increased speed of output, etc. that such a mechanism can be operationally defined beyond the mere postulation of its existence. But given the actual data to which the model has been applied, such quantitative attributions are unsatisfactory. A metaprocess, with the function of an evaluator, of a qualitative nature needs to be formulated for identifying the specific quality of internal state which cues the functioning of metaprocedural processes. As I have argued in numerous previous papers, whilst efforts towards procedural success are generated by both positive and negative feedback mechanisms, the evaluator operates by a positive feedback mechanism, i.e., it is not generated by failure of the system. Metaprocedural processes take what were disconnected procedures which were merely run and reorganize them into a new structure. Thus the notion of metaprocedures is not synonymous with top-down processes. The notion of metaprocedure stresses the important feature that the child works on her previous procedural success. This involves a qualitative change in behaviour, with success-oriented procedures being supplemented by organization-oriented ones.

8. Conclusions:

A number of recent studies of language acquisition have pinpointed the importance of children's reorganizational processes. With respect to naturalistic data, Bowerman (1981, 1982) described the progressive complexification of the child's semantic analyses of motion verbs, causative verbs, etc. Newport (1982) has argued that, in the case of the morphology of American Sign Language, second generation deaf children carry out complex internal morphological analyses on an input from first generation parents, which does not itself contain such morphology. In my work (Karmiloff-Smith, 1979a, etc.), I have shown from experimental data that children work on the determiner and gender systems of French, reorganizing the semantic, syntactic and morphophonological procedures successfully generated earlier. Hence, naturalistic and experimental data, as well as "nature's experiment" in the case of ASL input, show that in closed and open class morphology, in semantics and syntax, at the lexemic and discourse levels, children work on their earlier procedural representations, analyzing and

reorganizing them more effectively. Thus, it is not that we find success-oriented processes followed by organization-oriented processes only at the level of discourse as discussed in the present paper. I have shown in earlier work that this passage is also to be found at the morphemic and lexemic levels. The passage from success-oriented to organization-oriented procedures occurs recurrently throughout language development at different levels and in different aspects of the language. Normal language acquisition not only involves successfully mapping output and the adult input. On the contrary, children go beyond their success-oriented procedures and generate organization-oriented procedures spontaneously as part of their natural tendency to work on their procedural representations. Moreover, negative feedback from failure does not alone explain developmental change. Here and elsewhere I have argued that positive feedback through success triggers important developmental changes. The organization-oriented processes seem to be pervasive in language acquisition after the presystemic period through to late adolescence. This brings me to a series of questions in concluding this paper.

My first question is that if these processes are so pervasive in language acquisition, are they also pervasive in other domains? Is there an internal push towards overall organizational systems, whatever the domain, or is the push specific to language acquisition? One response might be that it is not as pervasive in other domains, except maybe for our future physicists or geometricians who will constantly attempt to pull various parts of their physical or geometric knowledge into a single system. After all, non-specialist adults often hold contradictory views about the physical environment and do not attempt to pull them together into a single framework. Yet we probably could also find in many adults indications of semantic concepts that are not fully analysed and are produced in limited contexts or even continuously misunderstood. The pervasiveness of metaprocedural processes being restricted to language learning is an open question (Karmiloff-Smith, in press, b). They may be equally pervasive across domains in early development and more pervasive in language as discourse organization starts to predominate.

To raise my second question, I shall quote from Roger Brown who, in 1973, wrote "...children work out rules for the speech they hear, passing from levels of lesser to greater complexity, simply because the human species is programmed at a certain period of its life to operate in this fashion on linguistic input" (quoted in Bowerman, 1981, my italics). Based on my arguments that there are deep-rooted analogies in children's interaction with linguistic and with non-linguistic problem spaces, Brown's assertion needs to be extended outside linguistic input. Surely the child generates processes to work on all problem spaces in a specifically human way, generating success-oriented procedures followed by organization-oriented procedures. To what extent this is preprogrammed, or developed in interaction with the environment, is a different issue. In the framework I have developed, I would attribute

to the neonate the capacity for metaprocedural processing from the outset, together with some domain-specific constraints. And I would suggest that metaprocedural processes are specifically human.

My reading of the ape literature (Karmiloff-Smith,1983) suggests that chimpanzees do not go beyond success and generate organization-oriented procedures for coping with language. They can learn a series of lexical terms, but they do not go beyond that and generate the organizational component of syntax. However, chimpanzees also seem not to go beyond success in problem-solving domains outside language. There, too, they generate success-oriented procedures to solve complex problems. It appears that the chimpanzee does not do what is typical of the human child, that is, go beyond successful attainment of their goal and generate organization-oriented procedures i.e. it does not seem to work on its internal representations at a metaprocedural level. If there is something specifically human about the human child, it is not language per se but the meta-procedural processes involved in both linguistic and non-linguistic development.

This brings me to my concluding question. Do children's linguistic processes stem from a store of cognitive processes which can be translated or realised as linguistic ones? Or, since these processes are so pervasive in language, are the processes initially driven by the needs of the linguistic system and only gradually tabbed as more general cognitive heuristics, translated into spatial, kinaesthetic and other representations? My response is that that both are probably true, but with different weightings at different moments of acquisition, which brings me back to an issue I raised in my introductory remarks. An adequate model of language acquisition will need to cover many interacting facets whose weightings may vary at different moments of acquisition. The interplay of data-driven and top-down control processes could originate in infant visual processes which may be the source of the earliest processes applied to the linguistic problem space. The link between early vision and language is beginning to receive new and subtle reanalysis by E. Anderson and her colleagues at USC (Dunlea, 1983). Similar processes may be discerned in early babbling (Elbers, 1982). Thus, the initial processes applied to language may come from a general store of cognitive processes. However, later, as language acquisition proceeds and as the constraints of processing a fast-fading message in real time become critical, the weighting could shift to the generation of processes for language being subsequently retranslated into more general cognitive heuristics. The source of these processes remains a very open question, but it is important to reiterate that developmental progress does not seem to be motivated by a drive for economy or success. Rather the 3-phase model suggests that the organism is driven by the desire for greater control over its own processes.

Whatever the definitive answers to the questions raised in this paper, I strongly believe that the process-oriented approach is a particularly fruitful way to rethink the relations between cognition and language and between human and non-human primate intelligence.

1. This Keynote Address at the Stanford Forum in Child Language Research, March 1983, was originally announced with the title "Beyond successful output: children's formal processing of the linguistic input." However, on planning the content, I found it turning out to be too close to an unpublished but widely circulated conference paper given earlier at Nijmegen (Karmiloff-Smith, 1979b). The change in title and content was thus made after the SFCLR programme was printed. I should like to thank Mike Anderson, Rick Cromer, Igor Karmiloff, and John Morton for comments on the first draft of this paper.
2. In previous papers I did not make an explicit distinction between "level" and "phase", although I avoided the term "stage" for intra-domain analyses.
3. Original French: "Eh bien, il y a une fille et un garçon. Le garçon il veut faire de la pêche, alors il prend le sceau. Et elle essaie de l'empêcher, la fille. Mais il le garde, et la fille court après. Quand même, il continue à pêcher. Elle s'assied sur le tronc d'arbre et elle commence à pleurer, la fille. Et lui, il attrappe encore quelques poissons.

References

Bowerman, M. Beyond communicative adequacy: from piecemeal knowledge to an integrated system in the child's acquisition of language, Keynote Address, 13th Annual Child Language Research Forum, Stanford University, April 24th, 1981.

Bowerman, M. Starting to talk worse: clues to language acquisition from children's late speech errors. In: S. Strauss (ed.) U-Shaped Behavioural Growth. New York: Academic Press, 1982.

Brown, R. A First Language. Cambridge, Massachusetts: Harvard University Press, 1973.

Chomsky, C. "The Acquisition of Syntax in Children from Five to Ten." Cambridge, Massachusetts: M.I.T. Press, 1969.

Dunlea, Anne. "On the role of visual information in early semantic development: evidence from the blind.", Paper given at MRC-CDU Colloquia Series, London, 17th March 1983.

Elbers, Loekie. "Operating Principles in repetitive babbling: a cognitive continuity approach.", Cognition, 12, 1982, 45-63.

Ferreiro, E., Othenin-Girard, Ch., Chipman, H. & Sinclair, H. "How do children handle relative clauses?." Archives de Psychologie, (1976) 172, 229-267.

Ferreiro, E. & Sinclair, H. Temporal relationships in language. Jl. Internat. de Psych., 1971, 6, 39-47.

Karmiloff-Smith, A. "Les métaphores dans l'action chez les enfants de 5 et de 12 ans.", paper given at the Symposium of the International Center for Genetic Epistemology, Geneva, June, 1975.

Karmiloff-Smith, A. "Adult simultaneous interpretation: a functional analysis of linguistic categories and a comparison with child development.", in D. Gerver and W. Sinaiko (Eds.) Language Interpretation and Communication, New York: Plenum, 1978, 369-383.

Karmiloff-Smith, A. A Functional Approach to Child Language, Cambridge, U.K., Cambridge University Press, 1979 (a).

Karmiloff-Smith, A. Language as a formal problem space for children. Unpublished paper presented at the MPG/NIAS Conference on "Beyond Description in Child Language Research.", Nijmegen, June, 1979 (b).

Karmiloff-Smith, A. Micro- and macro-developmental changes in language acquisition and other representational systems, Cognitive Science, 1979, 3 (2), 91-118, (c).

Karmiloff-Smith, A. Psychological processes underlying pronominalisation and non-pronominalisation in children's connected discourse. In: J. Kreiman and E. Ojedo (eds.) Papers from the Parasession on Pronouns and Ana- phora, Chicago, Chicago Linguistics Society, April 1980, 231-250.

Karmiloff-Smith, A. The grammatical marking of thematic structure in the development of language production. In W. Deutsch (ed.) The Child's Construction of Language, London, Academic Press, 1981 (a).

Karmiloff-Smith, A. Getting developmental differences or studying child development? Cognition, 1981, 10, 151-158 (b).

Karmiloff-Smith, A. A new representational code, or the new possibility of multiple representational codes? Commentary on D. Premack, The Codes of Man and Beasts. The Behavioural and Brain Sciences, 1983, 6, 149-150.

Karmiloff-Smith, A. Metalinguistic awareness and self-repairs as evidence of underlying cognitive processes. Cognition, in press (a).

Karmiloff-Smith, A. Children's problem solving, in A.L. Brown and M.E. Lamb (eds.) Advances in Developmental Psychology: Vol.3, New Jersey: Erlbaum. in press (b).

Karmiloff-Smith, A. and Inhelder, B. If you want to get ahead, get a theory, Cognition, 1974, 3 (3), 195-212.

Piaget, J. and Karmiloff-Smith, A. Conflicts entre symétries, Ch.IX, and, Un cas particulier de symétrie inférentielle, Ch. VIII, in J. Piaget (ed.) Recherches sur les catégories, Presses Universitaires de France: Paris, in press.

Sheldon, A. The role of parallel function in the acquisition of relative clauses in English, JVLVB, 1974, 13, 272-281.

Sinclair, H. The role of cognitive structures in language acquisition, in E. H. Lenneberg & E. Lenneberg (eds). Foundations of language: a multidisciplinary approach. New York: Academic Press, 1975.

Sinclair, H. & Ferreiro, E. Production et repetition des phrases au mode passif. Arch. de Psych., 1970, 40, 1-42.